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REVIEW ARTICLE

A Review on Microbial Characteristic in Ganges Water

Goutam Mukhopadhyay*, Remya Rajeevan

Department of Pharmacy, BCDA College of Pharmacy and Technology, Kolkata, West Bengal, India

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ABSTRACT

This project is mainly done to detect the several growths of harmful microorganisms in river Ganga and their effect on human and other animals. The main criteria of the project are to check the microbial growth in water and their colony characteristics by performing the biochemical tests of the microorganisms. The assessment of the quality of water was done by performing several plots followed by MPN method and the different parameters obtained from them are pH, conductivity of water, DO and biochemical oxygen demand ranges of water, fecal coliform value, and total coliform value. The microorganisms that are generally causes of the pollution of river Ganga are *Escherichia coli, Clostridium perfringens, Actinomyces sp., Aerobacter aerogenes, Arcobacter cloacae, Micrococcus sp., Salmonella sp., Staphylococcus aureus, Bacillus sp., Shigella sp., Streptococcus faecalis, diplococcus sp., Proteus vulgaris, Pseudomonas aeruginosa, Klebsiella sp., Clostridium welchii,* and *Bacillus anthracis.* The another causes of pollution of Ganga River are human wastes and industrial hazards. The main criteria of the review are to create a concern throughout the people of India to stop the extensive misuse of River Ganga.

Keywords: Assessment, biochemical tests, colony characteristics, concern, fecal coliform, Ganga, industrial hazards, microorganisms, MPN method

INTRODUCTION

The Ganga basin accounts for a little more than one-fourth (26.3%) of the country's total geographical area and is the biggest river basin in India, covering the entire states of Uttarakhand, Uttar Pradesh (UP), Bihar, Delhi, and parts of Punjab, Haryana, Himachal Pradesh, Rajasthan, Madhya Pradesh, and West Bengal. The Ganga basin is bound in the north by the Himalayas and in the south by the Vindhyas. The main river stream originates in the Garhwal Himalaya under the name of the Bhagirathi.

The ice-cave of Gaumukh at the snout of the Gangotri glacier, 4100 m above sea level, is recognized as the traditional source of River Ganga. The river cuts its path through the Himalayas and flows a distance of about 205 km from Gaumukh and transverses through two districts of Uttarakhand state, i.e., Uttarkashi and Tehri to reach Devprayg where another headstream, the Alaknanda, joins it to form Holy Ganga. The River Alaknanda is a major tributary of the River Ganga at Uttarakhand that begins at the confluence of the Satopanth and Bhagirath Kharak glaciers in Uttarakhand, and it travels approximately 190 km before meeting Bhagirathi.

After flowing through the northern-most part of Uttarakhand, the river flows through Uttar Pradesh, Bihar, Jharkhand, and West Bengal, and finally drains into the Bay of Bengal. The river traverses a length of 1450 km in Uttarakhand and Uttar Pradesh while touching the boundary between UP and Bihar for a stretch of 110 km. It then flows through Bihar, more or less covering a distance of 405 km. The length of the river measured along the Bhagirathi and Hooghly rivers during its course in West Bengal is about 520 km. The River Ganga has a large number of tributaries, namely Kali, Ramganga, Yamuna, Gomti, Ghaghara, Gandak, and Kosi. The River Yamuna, although a tributary of Ganga, is a river basin in itself. Its major tributaries are Chambal, Sind, Betwa, and Ken.[1]

Millions of people depend on the Ganges River. The Ganges River basin, with a land area of

***Corresponding Author:**
Goutam Mukhopadhyay
E-mail: gmukhopadhyay8@gmail.com

more than 1 million hectares (Mha), cuts across four South Asian countries, with India, Nepal, Bangladesh, and China making up 79, 14, 4, and 3% of the area of the basin. In the plains, it traverses about 2000 km before its confluence with the Brahmaputra and Meghna Rivers in Bangladesh. Benefits of water permeate the landscape of the Ganges. In its meandering course over 2500 km from Gangotri Glacier to the Bay of Bengal, fertile land and abundant water resources support both livelihoods and food security of more than 600 million people, of whom the majority live in rural areas. River water is an important source for fisheries and other riverine habitats, and also for navigation extending a stretch of 1500 km. Hydropower generation with an installed capacity of over 2000 megawatts is a major financial benefit of the river. The Ganges River is also considered sacred and revered by its riparian population, and its water is used for many religious and cultural activities, with more than 290 sites set up for tourists to access water along the major rivers and tributaries. Many ecologically sensitive sites, including lakes and wetlands, provide numerous ecosystem services, including maintenance of aquatic organisms for food and medicine, and space for flood control and nutrient recycling, and maintaining water quality.

Yet, the intense rainfall during the monsoon season and associated floods, combined with extremely low rainfall during the non-monsoon season and associated droughts, cause severe impacts on the large riparian population. Floods affect millions of people, and damage is caused of hundreds of millions of dollars worth of property and production annually Water scarcity, both physical and economic in the non-monsoon period due to inadequate water supply or insufficient development, respectively, barely allows cropping to only about 1.3 times the net sown area.[2]

ROLE OF RIVER GANGA

Economy

The Ganges Basin with its fertile soil is instrumental to the agricultural economies of India and Bangladesh. The Ganges and its tributaries provide a perennial source of irrigation to a large area. Chief crop cultivated in the area include sugarcane, lentils, oil seeds, potatoes, and wheat. Along the banks of the river, the presence of swamps and lakes provide a rich growing area for crops such as legumes, chilies, mustard, sesame, sugarcane, and jute. There are also many fishing opportunities along the river, though it remains highly polluted. Furthermore, the major industrial towns of Unnao, Kanpur, situated on the banks of the river with the predominance of tanning industries add to the pollution.[3]

Tourism

Tourism is another related activity. Three towns holy to Hinduism - Haridwar, Prayag (Allahabad), and Varanasi - attract thousands of pilgrims to its waters to take a dip in the Ganges, which is believed to cleanse oneself of sins and help attain salvation. The rapids of the Ganges also are popular for river rafting, attracting adventure seekers in the summer months. Furthermore, several cities such as Kanpur, Kolkata, and Patna have developed riverfront walkways along the banks to attract tourists.[4,5]

Some specific uses are listed below

1. Ganga River has remained important through the ages.
2. The areas along the banks of rivers have witnessed great cultural and economic progress since ancient times.
3. Rivers are integral parts of our folklore and folk-songs.
4. River water is a basic natural resource.
5. It is essential for human, agricultural, and industrial activities.
6. Ganga River deposits alluvial soils.
7. They provide the most productive agricultural lands to the country.
8. The Ganga delta has traditionally been the rice growing area.
9. An agriculture-dependent on the vagaries of the monsoon; get irrigation water from river.
10. Ganga River valley has dense and concentrated settlements.
11. Most of the large cities are located on the banks of rivers.
12. Rivers provide us with essential water supplies.
13. They also receive, dilute and transport wastes from settlements. Hence, they prove to be the biggest cleaners to towns and cities.
14. Industrial development has flourished

along the river because numerous industrial processes depend on water.
   a. Water is used as raw material.
   b. It is used to cool down the hot things.
   c. It is used in the generation of electricity.
15. Ganga River provides primary channels of inland waterways in the form of navigable waterways.
16. They also indirectly through their flatlands, where roads, railways lines, and other routes are built.
17. Rivers are also being used for recreation; tourist promotion and fishing activities in a big way.

Ecology and environment

Human development, mostly agriculture, has replaced nearly all of the original natural vegetation of the Ganges basin. More than 95% of the upper Gangetic Plain has been degraded or converted to agriculture or urban areas, running along the Himalayan foothills. Only one large block of relatively intact habitat remains Rajaji National Park, Jim Corbett National Park, and Dudhwa National Park.[6] As recently as the 16th and 17th centuries the upper Gangetic Plain harbored impressive populations of wild Asian elephants (*Elephas maximus*), Bengal tigers (*Panthera t. Tigris*), Indian Rhinoceros (*Rhinoceros unicornis*), gaurs (*Bos gaurus*), barasinghas (*Rucervusduvaucelii*), sloth bears(*Melursus ursinus*), and Indian lions (*Panthera leo persica*). In the 21st century, there are few large wild animals, mostly deer, wild boars, wildcats, and small numbers of Indian wolves, golden jackals, and red and Bengal foxes. Bengal tigers survive only in the Sundarbans area of the Ganges Delta.[7] The Sundarbans freshwater swamp ecoregion, however, is nearly extinct.[8] Threatened mammals in the upper Gangetic Plain include the tiger, elephant, sloth bear, and four-horned antelope (*Tetracerusquadricornis*).

Many types of birds are found throughout the basin, such as myna, *Psittacula* parakeets, crows, kites, partridges, and fowls. Ducks and snipes migrate across the Himalayas during the winter attracted in large numbers to wetland areas. There are no endemic birds in the upper Gangetic Plain. The great Indian bustard (*Ardeotis nigriceps*) and lesser florican (*Sypheotides indicus*) are considered globally threatened. The natural forest of the upper Gangetic Plain has been so thoroughly eliminated it is difficult to assign a natural vegetation type with certainty. There are a few small patches of forest left, and they suggest that much of the upper plains may have supported a tropical moist deciduous forest with sal (*Shorea robusta*) as a climax species.

A similar situation is found in the lower Gangetic Plain, which includes the lower Brahmaputra River. The lower plains contain more open forests, which tend to be dominated by *Bombax ceiba* in association with *Albizia procera*, *Duabanga grandiflora*, and *Sterculiavilosa*. There are early seral forest communities that would eventually become dominated by the climax species sal (*Shorea robusta*) if forest succession was allowed to proceed. In most places, forests fail to reach climax conditions due to human causes. The forests of the lower Gangetic Plain, despite 1000 of years of human settlement, remained largely intact until the early 20th century. Today only about 3% of the Eco region is under natural forest and only one large block, south of Varanasi, remains. There are over 40 protected areas in the Eco region, but over half of these are $<100^2$ km (39 sq mi). The fauna of the lower Gangetic Plain is similar to the upper plains, with the addition of a number of other species such as the smooth-coated otter (*Lutrogaleperspicillata*) and the large Indian civet (*Viverrazibetha*).[9]

It has been estimated that about 350 fish species live in the entire Ganges drainage, including several endemics.[10] In a major 2007–2009 study of fish in the Ganges basin (including the river itself and its tributaries, but excluding the Brahmaputra and Meghna basins), a total of 143 fish species were recorded, including 10 non-native introduced species.[11] The most diverse orders are Cypriniformes (barbs and allies), Siluriformes (catfish), and Perciformes (perciform fish), each comprising about 50%, 23%, and 14% of the total fish species in the drainage.

The main sections of the Ganges River are home to the gharial (*Gavialisgangeticus*) and mugger crocodile (*Crocodylus palustris*), and the delta is home to the saltwater crocodile (*C. porosus*).

RIVER GANGA AND POLLUTION

Passing through five states, the Ganga covers 26% of the country's landmass. Despite the enormous

amounts of money spent on cleaning it, the river continues to run polluted. Worse, the pollution is increasing even in stretches that were earlier considered clean. The Ganges suffers from extreme pollution levels, caused by the 400 million people who live close to the river.[12,13] Sewage from many cities along the river's course, industrial waste and religious offerings wrapped in non-degradable plastics add large amounts of pollutants to the river as it flows through densely populated areas.[14,15] The problem is exacerbated by the fact that many poorer people rely on the river on a daily basis for bathing, washing, and cooking. The World Bank estimates that the health costs of water pollution in India equal 3% of India's gross domestic product. It has also been suggested that 80% of all illnesses in India and one-third of deaths can be attributed to waterborne diseases.

Varanasi, a city of 1 million people that many pilgrims visit to take a "holy dip" in the Ganges, releases around 200 million L of untreated human sewage into the river each day, leading to large concentrations of fecal coliform (FC) bacteria. According to official standards, water safe for bathing should not contain more than 500 FC per 100 ml, yet upstream of Varanasi's ghats the river water already contains 120 times as much, 60,000 FC bacteria per 100 ml.[16,17]

After the cremation of the deceased at Varanasi's ghats, the bones and ashes are thrown into the Ganges. However, in the past thousands of uncremated bodies were thrown into the Ganges during cholera epidemics, spreading the disease. Even today, holy men, pregnant women, people with leprosy/chicken pox, people who had been bitten by snakes, people who had committed suicide, the poor, and children under 5 are not cremated at the ghats but are floated free to decompose in the waters. In addition, those who cannot afford the large amount of wood needed to incinerate the entire body, leave behind a lot of half-burned body parts.[18,19]

After passing through Varanasi and receiving 32 streams of raw sewage from the city, the concentration of FC in the river's waters rises from 60,000 to 1.5 million, with observed peak values of 100 million per 100 ml. Drinking and bathing in its waters, therefore, carry a high risk of infection.

The monitoring results obtained during 2011 under National Water Quality Monitoring Programme reflect that organic matter and bacterial population of fecal origin continue to dominate the pollution problem in River Ganga. The major water quality concerns as revealed from the monitoring results are pathogenic pollution as reflected through indicators, i.e. Total coliforms and FC, organic matter as reflected through biochemical oxygen demand (BOD) and salinity as reflected through conductivity. The observed range of water quality parameters of River Ganga for the year 2011 along with a summary for the year 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, and 2010 is given in Table 1 for comparative assessment of water quality trends over the years.

MICROORGANISM FOUND IN GANGA

Some of the important bacteria which were encountered in the Ganga waters include:

- *Escherichia coli.*
- *Clostridium perfringens.*
- *Actinomyces sp.*
- *Enterobacter aerogenes.*
- *Arcobacter cloacae.*
- *Micrococcus sp.*
- *Salmonella sp.*
- *Staphylococcus aureus.*
- *Bacillus sp.*
- *Shigella sp.*
- *Streptococcus faecalis.*
- *Diplococcus sp.*
- *Proteus vulgaris.*
- *Pseudomonas aeruginosa.*
- *Klebsiella sp.*
- *Clostridium welchii.*
- *Bacillus anthracis*.

Total bacterial density and qualitative variations are maximum in the rainy seasons and minimum during the winters. The main source of bacterial contamination at most of the sites is sewage discharge. Air marginal soil decomposing plant, materials and cattle washing constituted the other major sources of bacterial contamination.[20]

CHARACTERISTICS OF MICROORGANISM AND DISEASE CAUSED

E. coli

E. coli is a Gram-negative, facultatively anaerobic, rod-shaped, coliform bacterium of the genus

Table 1: Range of water quality parameters during the years – 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, and 2011 in River Ganga

Year	No of monitoring locations	Observed range of water quality parameters						
		Temp. (®C)	pH	Conductivity (μmhos/cm)	DO (mg/l)	BOD (mg/l)	TC (MPN/100 ml)	FC (MPN/100 ml)
2002	34	3–34	6.4–9.0	19–2720	2.7–11.5	0.5–16.8	300–25 × 10^5	20–11 × 10^5
2003	34	4–34	6.8–8.9	49–1323	4–11	0.8–27	47–45 × 10^5	26–12 × 10^5
2004	34	5–35	7–8.8	72–4080	0.3–13.2	0.7–14.4	11–45 × 10^5	11–7 × 10^5
2005	39	4–39	6.1–9	23–1696	3.2–12.8	0.1–15.2	13–45 × 10^5	13–11 × 10^5
2006	39	9–33	7.0–8.9	97–5620	2.2–11.9	0.1–16.4	1–25 × 10^5	17–11 × 10^5
2007	39	4–33	6.1–8.8	23–5040	1.4–11	0–14	0–28 × 10^5	0–7 × 10^5
2008	39	2.5–35.5	6.1–8.9	39–6320	1.2–11.6	0.5–21.0	0–101 × 10^5	0–85 × 10^4
2009	57	4–37	6.5–8.9	68–4460	4.3–11.2	0.2–16	2–65 × 10^4	0–4 × 10^5
2010	57	4–35	6.7–9.0	21–5250	3.6–12	0.2–15	3–14 × 10^5	2–4 × 10^5
2011	57	3–37	6.7–9.1	49–10240	4–14.3	0.2–11	5–25 × 10^5	5–11 × 10^5

TC: BOD: Total coliform, FC: Fecal coliform, Biochemical oxygen demand

Escherichia that is commonly found in the lower intestine of warm-blooded organisms (endotherms).[21,22] Most *E. coli* strains are harmless, but some serotypes can cause serious food poisoning in their hosts, and are occasionally responsible for product recalls due to food contamination.[23,24] *E. coli* reaches the Ganga River through fecal matter. The bacterium grows massively in the fresh fecal matter under aerobic conditions for 3 days [Figure 1]. Most *E. coli* strains do not cause disease, but virulent strains can cause gastroenteritis, urinary tract infections, neonatal meningitis, hemorrhagic colitis, and Crohn's disease.[25] Common signs and symptoms include severe abdominal cramps, diarrhea, hemorrhagic colitis, vomiting, and sometimes fever. In rarer cases, virulent strains are also responsible for bowel necrosis (tissue death) and perforation without progressing to hemolytic-uremic syndrome (HUS), peritonitis, mastitis, septicemia, and Gram-negative pneumonia. Very young children are more susceptible to develop severe illness, such as HUS; however, healthy individuals of all ages are at risk to the severe consequences that may arise as a result of being infected with *E. coli*.[26] There is one strain, *E. coli* 0157:H7 that produces the Shiga toxin (classified as a bioterrorism agent). This toxin causes the premature destruction of the red blood cells, which then clog the body's filtering system, the kidneys, and causing HUS. Signs of HUS, include decreased frequency of urination, lethargy, and paleness of cheeks, and inside the lower eyelids.

C. perfringens

C. perfringens (formerly known as *C. welchii*, or *Bacillus welchii*) is a Gram-positive, rod-shaped, anaerobic, spore-forming pathogenic bacterium of the genus *Clostridium*.[27] *C. perfringens* is ever present in nature and can be found as a normal component of decaying vegetation, marine sediment, the intestinal tract of humans and other vertebrates, insects, and soil. It has the shortest reported generation time of any organism at 6.3 min in thioglycollate medium [Figure 2].

Infections due to *C. perfringens* show evidence of tissue necrosis, bacteremia, emphysematous cholecystitis, and gas gangrene, which is also known as clostridial myonecrosis. The toxin involved in gas gangrene is known as α-toxin, which inserts into the plasma membrane of cells,

Figure 1: *Escherichia coli*

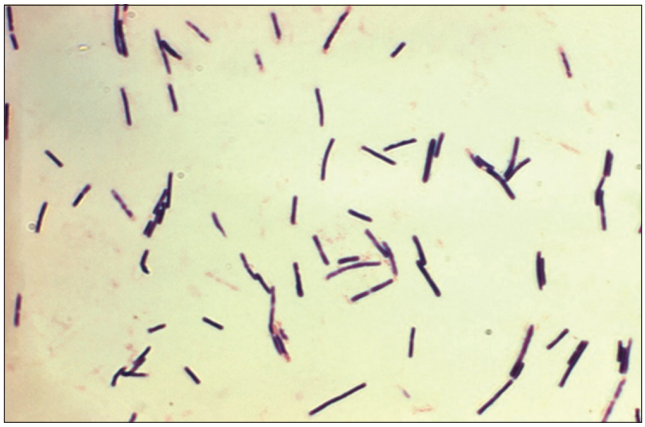

Figure 2: *Clostridium perfringens*

producing gaps in the membrane that disrupt normal cellular function. *C. perfringens* can participate in polymicrobial anaerobic infections. *C. perfringens* is commonly encountered in infections as a component of the normal flora. In this case, its role in disease is minor.

The action of *C. perfringens* on dead bodies is known to mortuary workers as tissue gas and can be halted only by embalming.

Actinomyces

Actinomyces is a genus of the Actinobacteria class of bacteria. They are all Gram-positive. *Actinomyces* species are facultatively anaerobic (except *A. meyeri* and *A. israelii* both obligate anaerobe), and they grow best under anaerobic conditions. *Actinomyces* species may form endospores, and while individual bacteria are rod-shaped, *Actinomyces* colonies form fungus-like branched networks of hyphae [Figure 3].[28]

Actinomyces species are ubiquitous, occurring in soil and the microbiota of animals, including the human microbiota. Certain species are commensal in the skin flora, oral flora, gut flora, and vaginal flora of humans and livestock.[29] They are also known for causing diseases in humans and livestock, usually when they get an opportunity to gain access to the body's interior through wounds. As with other opportunistic infections, people with immunodeficiency are at higher risk. Actinobacteria are normally present in the gums and are the most common cause of infection in dental procedures and oral abscesses. Many *Actinomyces* species are opportunistic pathogens of humans and other mammals, particularly in the oral cavity. In rare cases, these bacteria can cause actinomycosis, a disease characterized by the formation of abscesses in the mouth, lungs, or the gastrointestinal tract. Actinomycosis is most frequently caused by *A. israelii*, which may also cause endocarditis, though the resulting symptoms may be similar to those resulting from infections by other bacterial species. *Aggregatibacter actinomycetemcomitans* has been identified as being of note in periodontal disease.

The genus is typically the cause of oral-cervicofacial disease. It is characterized by a painless "lumpy jaw." Lymphadenopathy is uncommon in this form of the disease. Another form of actinomycosis is thoracic disease, which is often misdiagnosed as a neoplasm, as it forms a mass that extends to the chest wall. It arises from aspiration of organisms from the oropharynx. Symptoms include chest pain, fever, and weight loss. Abdominal disease is another manifestation of actinomycosis. This can lead to a sinus tract that drains to the abdominal wall or the perianal area. Symptoms include fever, abdominal pain, and weight loss.[30]

Micrococcus sp.

Micrococcus is a genus of bacteria in the Micrococcaceae family. *Micrococcus* occurs in a wide range of environments, including water, dust, and soil. Micrococci have Gram-positive spherical cells ranging from about 0.5 to 3 micrometers in diameter and typically appear in tetrads. They are catalase positive, oxidase positive, indole negative, and citrate negative. Micrococcus has a substantial cell wall, which may comprise as much as 50% of the cell mass. The genome of Micrococcus is rich in guanine and cytosine (GC), typically exhibiting 65–75% GC-content. Micrococci often carry plasmids that provide the organism with useful traits [Figure 4].

Micrococcus is generally thought to be a saprotrophic or commensal organism, though it can

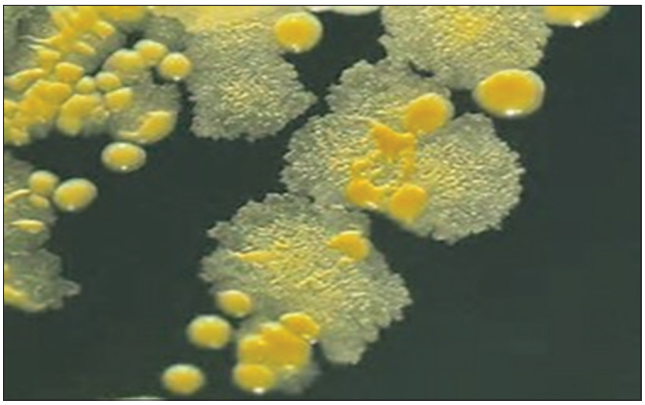

Figure 3: *Actinomyces*

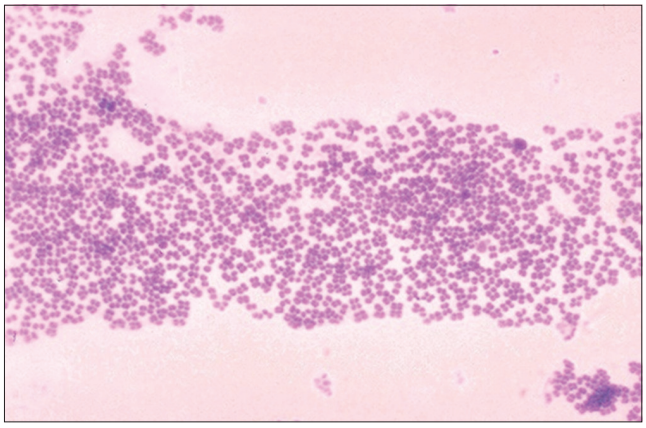

Figure 4: *Micrococcus* sp.

be an opportunistic pathogen, particularly in hosts with compromised immune systems, such as HIV patients.[31] It can be difficult to identify Micrococcus as the cause of an infection, since the organism is normally present in skin microflora, and the genus is seldom linked to the disease. In rare cases, death of immune compromised patients has occurred from pulmonary infections caused by Micrococcus. Micrococci may be involved in other infections, including recurrent bacteremia, septic shock, septic arthritis, endocarditis, meningitis, and cavitating pneumonia (immunosuppressed patients).

Salmonella

Salmonella is a genus of rod-shaped (bacillus) Gram-negative bacteria of the Enterobacteriaceae family. The two species of *Salmonella* are *Salmonella enterica* and *Salmonella bongori*. *Salmonella enterica* is the type species and is further divided into six subspecies that include over 2,500 serotypes [Figure 5].[32]

Salmonella species are non-spore-forming, predominantly motile enterobacteria with cell diameters between about 0.7 and 1.5 µm, lengths from 2 to 5 µm, and peritrichous flagella (all around the cell body). They are chemotrophs, obtaining their energy from oxidation and reduction reactions using organic sources. They are also facultative anaerobes, capable of generating ATP with oxygen ("aerobically") when it is available; or when oxygen is not available, using other electron acceptors or fermentation ("anaerobically"). *S. enterica* subspecies are found worldwide in all warm-blooded animals and the environment. *S. bongori* is restricted to cold-blooded animals, particularly reptiles.[33]

Salmonella species are intracellular pathogens: Certain serotypes cause illness. *Nontyphoidal serotypes* can be transferred from animal-to-human and human-to-human. They usually invade only the gastrointestinal tract and cause *Salmonella* food poisoning; symptoms resolve without antibiotics. However, in Sub-Saharan Africa, they can be invasive and cause paratyphoid fever, which requires immediate treatment with antibiotics. *Typhoidal serotypes* can only be transferred from human-to-human and can cause *Salmonella* food poisoning, typhoid fever, and paratyphoid fever. Typhoid fever occurs when *Salmonella* invades the bloodstream - the *typhoidal form*; or in addition spreads throughout the body, invades organs, and secretes endotoxins - the *septic form*. This can lead to life-threatening hypovolemic shock and septic shock and requires intensive care including antibiotics.

Staphylococcus Aureus

S. Aurėus (also known as *golden staph*) is a Gram-positive, round-shaped bacterium that is a member of the Firmicutes and is frequently found in the nose, respiratory tract, and on the skin. It is often positive for catalase and nitrate reduction and is a facultative anaerobe that can grow without the need for oxygen.[34] Although *S. aureus* is not always pathogenic (and can commonly be found existing as a commensal), it is a common cause of skin infections including abscesses, respiratory infections such as sinusitis and food poisoning. Pathogenic strains often promote infections by producing virulence factors such as potent protein toxins, and the expression of a cell-surface protein that binds and inactivates antibodies. The emergence of antibiotic-resistant strains of *S. aureus* such as methicillin-resistant *S. aureus* is a worldwide problem in clinical medicine. Despite

Figure 5: *Salmonella*

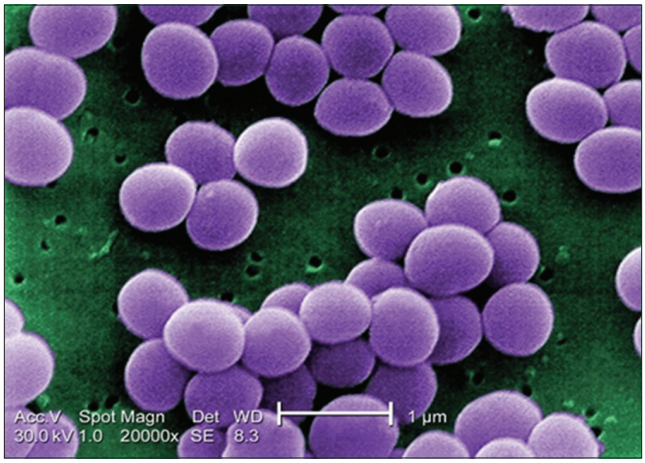

Figure 6: *Staphylococcus Aureus*.

much research and development, there is no approved vaccine for *S. aureus* [Figure 6].

An estimated 20%–30% of the human population are long-term carriers of *S. aureus* which can be found as part of the normal skin flora, in the nostrils, and as a normal inhabitant of the lower reproductive tract of women.[35,36] *S. aureus* can cause a range of illnesses, from minor skin infections, such as pimples, impetigo, boils, cellulitis, folliculitis, carbuncles, scalded skin syndrome, and abscesses, to life-threatening diseases such as pneumonia, meningitis, osteomyelitis, endocarditis, toxic shock syndrome, bacteremia, and sepsis.

WHAT IS THE SOLUTION FOR GANGA POLLUTION? WHAT SHOULD WE DO?

Provide for water in the river for ecological flow and dilution action plan

Ecological flow will be mandatory in all stretches of the river. In the upper stretches, where the requirement is for critical ecological functions as well as societal needs, it will be mandated at 50% for mean season flow and 30% for other seasons. In the urbanized stretches, it will be mandated based on the quantum of wastewater released into the river and calculated using a factor of 10 for dilution. All Central Governments funding under the National Mission for Clean Ganga will be conditional on the quantum of ecological flow made available by the state.

Modification of sewage conveyance systems and in-situ treatment of sewage

Therefore, the conveyance of waste must be re-conceptualized and implemented at the time of planning treatment plants. This will then lead to innovative ideas for controlling pollution in drains - *in situ* - treatment of sewage as well as local treatment and reuse.

Furthermore, as the plans are premised on the acceptance of non-availability of sewerage networks, the discharge of treated effluent will be carefully reconsidered and designed. The treated effluent will not be "mixed" with the untreated waste in drains. Instead, all treated effluent will either be designed for reuse or it will be discharged directly into the river.

Action plan

1. Do not plan for STPs; instead, plan for drains that are discharging into the Ganga. Prioritize action based on drains with high pollution load, so that impact is immediate.
2. Make a drain-wise plan, which looks to treat waste without first building the internal conveyance system. Plan for interception and pumping to sewage treatment plant. Furthermore, plan for *in situ* drain treatment, as it will bring down pollution levels of discharge that is not intercepted. Bottom-line, use the open drain for treatment of waste. This is the reality that we cannot ignore.
3. Ensure that there is a plan for treated effluents - do not treat and put back treated wastewater into open drain, where it is again mixed with untreated waste. Instead, plan deliberately for utilization or disposal of treated effluent.
4. Plan the reuse and recycling of treated effluent, either for city water use or agricultural use. Plan deliberately. Implement this objective.
5. Plan to treat wastewater before it discharges

into the river. Either intercept drain before discharge to a treatment plant or build a treatment plant on the bank of the river for the remaining waste.

6. No untreated waste should be disposed into the river. The provision for ecological flow for assimilation of waste will be critical for setting standards for discharge. If there is no water in the river, only waste that is discharged, then standards have to be so stringent that they can meet bathing or even drinking water quality. This will be prohibitively expensive, and it makes no economic sense (in a poor country) to clean wastewater to drinking water quality and then not use it for this purpose.
7. If all this is not acceptable or does not get operationalized, then the only alternative for river cleaning is to ask cities to get their water supply downstream of their discharge points. In other words, they will have to use their wastewater and then invest to clean it to turn it into drinking water for their citizens.
8. Otherwise, we must learn that we all live downstream. Today, each city's waste is fast becoming the next city's water supply.

Efficient funding should be made available for the Ganga cleaning programs

Even if the current situation requires Central Government assistance for capital and operational costs, this is not tenable in the long run or for the scale of pollution control infrastructure that is required to clean the river. As long as states do not have the responsibility to build sewage treatment systems or to maintain these they have no incentive to plan for affordable solutions or even to implement projects. In the current system, the Central Government will pay the full capital cost for infrastructure and even pay for running the plant. There is absolutely no incentive to plan the water-waste infrastructure for affordability and sustainability.

Action plan

Build clear conditionality in Central Government funding, that it will match financial support to the quantum of ecological flow released by the state in the river or payment for capital and operation of infrastructure. As water utilities do not have the infrastructure to charge for operations, build innovative systems for collection of pollution payments at the city/settlement level.

Strict implementation of the industrial pollution norms

It is clear that industries must be able to meet discharge standards that have been legally set in the country. In UP, records show that almost all industries inspected by the Central Pollution Control Board in 2013 are in breach of existing standards. It is time for tough action. Nothing less than this will solve the problem.[37]

DISCUSSION

Pollution of the Ganges (or Ganga), the largest river in India, poses significant threats to human health and the larger environment. This pollution, in turn, encourages the growth of a wide variety of harmful microorganisms which cause various infectious diseases in human as well as animals. Severely polluted with human waste and industrial contaminants, the river provides water to about 40% of India's population across 11 states, serving an estimated population of 500 million people or more, more than any other river in the world.

Today, Ganges is considered to be the fifth most polluted river in the world. However, pollution has been an old and continuous process in the river as by the time people were finally speaking of the Ganges as polluted, stretches of over 600 km were essentially ecologically dead zones.

CONCLUSION

A number of initiatives have been undertaken to clean the river but failed to deliver the desired results. After getting elected, India's Prime minister Narendra Modi affirmed to work in cleaning the river and controlling pollution. Subsequently, the Namami Ganga Project was announced by the government in the July 2014 budget. An estimated Rs 2,958 Cores have been spent till July 2016 in various efforts in cleaning up of the river. According to Scientific Studies Ganga will disappear till 2035 and the whole North India (UP, Bihar, Uttarakhand, West Bengal, and Jharkhand) will become a desert.

Saving Ganga means Saving your own life. Hence, everyone should take an oath to save the Ganga.

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